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LENS FACTS
YOU SHOULD KNOW

in the choice and use of photographic lenses for different branches of photography: written from the practical viewpoint of everyday use:

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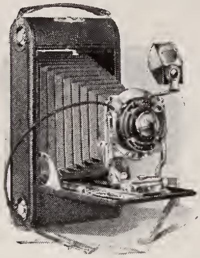

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Lens Facts You Should Know

The action of a lens is not the easiest part of the photographic process to explain, although it is the most completely known. Nobody can tell us exactly what happens when the emulsion of a plate is exposed to light—or, at any rate, they have half a dozen different accounts,—but lenses follow established laws of optics, which are known from A to Z. So far as the use of lenses is concerned, photographic optics is easily within the ready comprehension of even those of us with no knowledge of mathematics. Many text-books have weighted the subject with mathematical symbols, and others, professing to be elementary, fail, I think, in trying to explain too much at once. In actual fact, the action of a lens depends on various of its properties which can be considered separately from others. As we shall see, we can learn how its focal length enters into photographic work without troubling about the diaphragm; we can explore the effect of the diaphragm without worrying about the characteristics of different types of lenses. On this plan, we shall have to take very little for granted as we proceed, and we shall find, I hope, that ordinary common sense, *plus* a little arithmetic, is sufficient for a working knowledge of lenses.

What a Lens Does

Let us first get into our minds the essential nature of a lens' action. It is to bend rays of light which fall upon it and bring them all to one point on the other side of the

lens. It has this effect upon each separate set of rays which fall upon its surface from all the points which make up the scene or object before it. Imagine some object such as the knob on the top of a flagstaff, so far off that it seems a mere point to the eye. Light falls upon it and is reflected in all directions, up, down, and sideways. Such reflection of light is, of course, the means by which we see things. A small proportion of the whole number of rays from our distant flagstaff-knob fall upon the lens, but instead, then, of passing straight on, each is bent (refracted) so that all converge to meet at a point beyond the lens; forming there a minute image of the knob. We have imagined our flagstaff at a great distance, so that for practical purposes the rays are parallel when they reach the lens. The point in space at which they meet on the other side of the lens—i.e. after passing through the lens, is the "focus," or, more correctly, the "focus for parallel rays," and the distance from some point in (or near) the lens to the focus is the "focal length" of the lens. It is almost obvious that, if the rays come from a point so appreciably nearer to the lens that they are not parallel when they reach the glass surface, the focus will be farther back than for parallel rays: the lens exerts a certain bending action and no more, and if it starts with a handicap in the shape of actual divergence of the rays falling upon it, the convergence it produces is proportionately less. Hence, in speaking of (and measuring) "focal length," it is understood to be "for parallel rays," otherwise it has no definite or exact value whatever.

The Focal Plane

Rays fall upon the lens in the same way from every point in the subject before it, just as from the knob of our imaginary flagstaff; and the set from each point, in passing through the lens, is caused to meet in a point which lies to right or left, above or below the image of the knob, according to their relative positions in the original scene. Thus numbers of image-points are formed behind the lens, and this assemblage of image-points forms the "focal plane," which is the surface at which the whole image of the subject or scene is formed,

and is rather unfortunately named "plane," for it is hardly ever perfectly flat. The shape of the surface depends on the type of lens, but with none is it a truly dead flat. "Field" is the better word for it.

What is Focusing?

So we understand that there is one distance behind the lens at which an object is formed, point for point, as an image by the lens, and that this picture-image can be seen by the eye by placing a ground-glass screen there. Focusing, for our present purpose, consists in moving the lens or the ground-glass, so that the latter indicates the position of the image. If the ground glass is in front of the focal plane (or surface of image), the whole picture appears blurred because the rays at this point have not fully converged—each set to a point. If it is behind the focal plane, the picture is again indistinct from the rays crossing each other and spreading out to form tiny disks, instead of points. There is one position in which (without the aid of a diaphragm) a sharp image is formed by the lens, and can be recorded by the sensitive plate. As we shall see later on, focusing in practical work is more than this, and involves the use of the stop or diaphragm and of the camera back, as well as the utilization of the shape of the focal plane or focal field of the lens.

Focal Length and Back Focus

The proper name for the distance from a point in (or near) the lens to the sharp image of a distant object is the "focal length," but the common term "focus" will be used here, where no confusion is caused. "Back focus" is a term often met in makers' catalogues. It is the distance from the back of the lens tube to the ground-glass when a distant image is in focus, and serves simply as an indication of the camera extension required by the lens. It may be greater or less than the focal length according to the construction of the lens, such differences, as we shall see later, being of practical service. Here let us realize first that the focus (focal length) is a measure of the bending power of the lens, and has the chief effect of determining the size or scale of picture-image produced at a given distance from the object. The longer the focus, the larger is the

image of an object which a lens forms on the focusing screen. If the object is a long way from the camera, the size of the image is proportional to the focal length of the lens. For example, if a lens of 6-inch focus renders a distant house 2 inches high in the plate, one of 12-inch focus will render it 4 inches in height, from the same standpoint. This simple rule does not work exactly when the object is comparatively near to the camera, but the difference is not enough to "cut any figure," except in photographing something exactly to scale. The rule is quite near enough as a basis for general practical work. Thus, in using one of the casket sets of lenses, giving a wide range of focal length, if the 8-inch lens produces a 2-inch image on the plate, and we want one of 5 inches, a single rule of three sum will tell us the focus of lens which is needed, viz., $8 \times 5 \div 2 = 20$ inches.

Focal Length and Angle of View

Naturally, when the subject is reproduced on a larger scale by using a lens of longer focus, less of it is included on the plate. With a given size of plate, you can't have it both ways. This is what is meant by "angle of view." It is a term which signifies the action of a lens, but only in relation to some particular size of plate. It means that when a given size of plate is filled by the image, the "angle of view" is wide or narrow according as the focus of the lens is short or long as compared with the base line of the plate or film. A medium angle of view is given by a lens of focus nearly double the longer side of the plate, viz., 9 inches on a 4 x 5 plate; 13 inches on a 5 x 7; and 19 inches on an 8 x 10 plate. A wide angle is given by a lens of focus rather less than the shorter side of the plate; and a narrow angle is obtained by a lens of focus nearly three times the long side of the plate. Or you may look at the matter the other way about, and consider that with one lens, say a lens of 5-inch focus, used on a 5 x 7 plate, its action is that of a wide angle over the whole plate, that of a medium angle over a central part 3 x 2 inches, and a narrow angle over a smaller area of 2 x 1 inches. There is a practical meaning to this, viz., that so far as the effect of angle is concerned it doesn't

matter whether your picture is made by using a long-focus lens on, say, a 4 x 5 plate, or a lens of much shorter focus on a small portion only of that plate. The only difference is the size or scale of the picture. If you enlarge the smaller negative, it will be identical with the larger, except that it may not be quite so sharp.

Practical Effect of Angle of View

Now what is the effect of different angles of view, apart from the amount of subject included? It is of practical moment, though unfortunately largely disregarded and confused with other things. Why is it better to use a long-focus lens on a plate or, when a shorter-focus lens is employed, to dispense with a considerable marginal part of the negative. The reason is that the angle at which the lens works fixes the "drawing" of the photograph. If the angle is too wide, the effect produced is unnatural. It is palpably out of conformity with the impression obtained by the eye. It is true that the eye and the camera are very different instruments. We cannot expect to make the camera altogether replace the eye as regards the effect produced, but we can remove the glaring inconsistencies which arise from the lens forming its image over too wide an angle. They are seen in the exaggeration of the foreground, or dwarfing of the distance. Most photographs of roads or streets show enormous breadth in the foreground, and an absurd dwarfing of houses in the distance, as compared with those near at hand. A garden acquires the appearance of a park, in the photograph, owing to the false impression of distance. We so rarely return to the scenes we photograph and compare them with our prints that we are not alive to this fault. In portraiture it *is* recognized: we avoid exaggerated hands and knees by using a long-focus lens. The same fault is pronounced in photographing many subjects which recede fairly directly from the camera, e. g., an automobile, shown end on, a procession, and particularly things like chairs, cups, vases, which are often photographed over an excessively wide angle in the effort to get a large-size image on the plate with a normal-focus lens. The remedy is to use a lens whose focus is greater than the base measure of the plate used.

Standpoint Perhaps you have read that focal length has nothing to do with the perspective of the subject; that perspective is solely conditioned by the standpoint of the camera. Taken literally, both of those statements are perfectly true, and they are strictly in accordance with what I have written on angle of view. The latter and the position of the camera are interdependent. With any lens, if you want to work at a narrow angle and to include the subject on the plate, you must take a distant standpoint. If you approach nearer, you don't get in all you want. In presenting the subject here, I have chosen to look at it from the point of view of angle included on the plate, rather than by way of advocating a distant standpoint. Human nature being what it is, it is a more emphatic plan to say: "Use a lens of 10-inch focus on a 4 x 5 plate" than it is to say: "Avoid too near a standpoint for the camera." The user of the 10-inch lens *has* to take a different standpoint in order to include the subject on the plate. If all he wants is not included, then, of course, he must use a shorter focus. In landscape photography and other branches, it is just as practicable to use the long-focus as the short: there is plenty of room to get back and the lesser amount of subject is better pictorially. For interiors and much commercial photography of buildings, it is impossible to get far enough away from the subject to work at a narrow angle; and then a shorter-focus, or even a wide-angle, lens must be used. And as I refer here to "wide-angle" as a special kind of lens, which it is not, I ought to explain why I do so.

The Wide-Angle Lens We have seen that long focus (as compared with the plate) means narrow-angle; short focus, *vice versa;* and that a lens may act as narrow-, medium-, or normal-angle according to the size of the plate. It requires to be noted, however, that the ability to cover a plate sharply over a wide angle is the result of quite special construction. Hence, a lens which will do this is probably designated "wide-angle" by its makers. It ceases to be a wide-angle when used on a much smaller plate. As we shall see, many modern lenses, when used with a

small stop, serve almost equally well as the special wide-angles; that is, they cover a plate considerably larger than the one for which they are listed. The fact is sometimes overlooked by the photographer, who thinks that he must get a special wide-angle lens for this or that special subject, when he may have among his other instruments an anastigmat which, with stopping down, will answer perfectly.

Some Angles of View

Perhaps, before I leave this subject of angle of view, I had better give a few round figures for focal lengths which afford various angles on plates in general use. The following table does this:

Plate Inches	Narrow-Angle (20°)	Medium-Angle (30°)	Normal-Angle (45°)	Wide-Angle (72°)
4 x 5	14 inches	9 inches	6 inches	3½ inches
5 x 7	20 "	13 "	8½ "	4¾ "
8 x 10	28 "	19 "	12½ "	7 "

By normal-angle in column 4, I mean the angle given by the lenses usually fitted by the makers of hand-cameras or camera sets. Such focal lengths are fitted or recommended because they allow of inclusion of most ordinary subjects on the plate. It is, nevertheless, a fairly wide angle, and much inferior to one of 20° or even 30° as regards securing pleasing drawing or perspective of the subject. Those who want to find the precise angle included by any lens on any size of plate may use the chart given on page 54 of "Figures, Facts, and Formulæ": THE PHOTO-MINIATURE NO. 134.

Measuring Focal Length

Having said so much on the effect of focal length, it is time to give one or two simple but sufficiently exact methods of measuring it. In the case of a single or landscape lens (that is, one composed of one glass cell only), or in that of an R R lens (before the days of anastigmats), all that is necessary is to focus sharply on a distant object, and then to measure from the ground-glass to the back surface of the single lens, or to the stop in the case of an R R. But that plan is liable to considerable error

with some more modern lens. In defining focal length, I said it was the distance from a point in or near the lens to the sharp image of a distant object. It is not easy to find where the point "in or near" the lens really is, with many modern types and lenses, and therefore the best thing is to use a method which dispenses with a knowledge of its position, viz., as follows: First focus the lens on an object at an "infinite" distance. By "infinite" we mean at least five hundred times the focal length of the lens approximately. Farther does not matter; somewhat nearer will affect the measurement very little. Usually a distant spire, house, or chimney, can be found. With the "infinite" object in focus, mark the position of any movable part of the lens-board on the fixed-camera base-board. Then place some marked object, such as a foot-rule, in front of the camera, and focus to get the image the same size as the original, but moving the camera as a whole, using the same focusing adjustment you used in the first instance.

The object is to measure exactly how far the lens must be moved farther from the plate in order to obtain a same-size image. This distance, which is easily found by measuring the separation between the two positions of the moving base-board, is the focal length of the lens. It is an easy method and, with careful focusing and measurement, correct to within one-sixteenth of an inch.

Focal Distances

If we know the focal length of a lens, it is a very simple matter to calculate the distances from lens to plate and from lens to original in copying; or to paper and negative in enlarging. Calculations of this kind will save an enormous amount of trouble when making copies, designing enlarging-boxes, and similar work. It will be understood that, in photographing such near objects, the rays which reach the lens are not parallel; they are still more or less divergent, consequently they are brought to a focus farther behind the lens than are parallel rays from a distant object. In other words, the lens has to be racked out farther, and the amount of this racking-out follows a very simple rule, which we

can use without encumbering ourselves with unnecessary mathematical formulas.

Extra Focal Length When copying or photographing, say an 8 x 10 photograph down to 4 x 5 size, the extension of the camera, as we know, has to be that for a distant object *plus* a little bit more. The "little bit more" is not a chance distance, but depends on the focal length of the lens and on the degree of reduction. It is, in fact, the focal length divided by the degree of reduction. As we know both of these, it is an easy matter to calculate the "little bit more," or "extra focal distance," as the opticians prefer to call it. In our example, the degree of reduction is 2. It is linear reduction, not the reduction of area, that we are concerned with, and $10 \div 5 = 2$. Suppose our lens is of 8 inches focal length, then the extra extension (beyond focus for distant objects) is $8 \div 2 = 4$. Note that the whole extension—lens to plate—is not necessarily the focal length and the extra bit added together, viz., 12 inches. With single lenses and old R R's it will be that, but some modern lenses are peculiar in having a back focus which is appreciably shorter (with some, longer) than the focal length. But the rule, as just given, holds good in all cases: Divide focal length by degree of (linear) reduction. The result is extra extension or rack-out of camera required beyond that for distant objects.

The same rule is applied in a still simpler way to find the distance the original requires to be from the lens. This distance is the focal length of the lens, *plus* the focal length *multiplied* by the degree of reduction. In our example: 8 (focal length) + 8 (focal length) × 2 (degree of reduction) = 8 + 16 = 24 inches.

This rule holds good in all copying and enlarging work. In copying on a reduced scale, the shorter distance is from lens to plate; in copying on an enlarged scale, or in enlarging from a negative in the ordinary way, the longer distance is from lens to plate or paper.

Conjugate Foci The full distances on either side of the lens from it to the original (in one direction), and to the sharply focused image (in the other), are called by opticians the "con-

jugate foci," and stand always in a fixed relation to each other. Whatever the focal length of the lens, the larger conjugate focus is equal to the smaller multiplied by the degree of reduction; or, what is the same thing, the smaller is equal to the larger divided by the degree of reduction. But this rule is true only when we know exactly where to measure from "in or near" the lens. It is easy to apply it in the case of single and old doublet lenses, measuring from the glass surface or the diaphragm respectively; but, with more modern and complex types of lenses, one would require to find out by special tests from what point to measure forward from lens to original and back from lens to plate. The system of measuring the extra focal distance largely avoids this difficulty, and for that reason I recommend it as a most practical working method. There is no more in it than the two rules I have given in the preceding paragraph; calculations can often be done in the head or, at the worst, on a half-sheet of note-paper. Remember that in all calculations you should imagine two bars, each the focal length (or back focus) of the lens, one sticking out in front of the lens and one behind. This will remind you to add one focal length to each calculated distance of extra extension or distance of original from the lens.

Focal Length and the Studio

The problem of deciding whether a lens is suitable for a studio or room as regards focal length may be worked out by the same easy method. As we have already seen, it is best to use the longest focus which space permits for the sake of better drawing or perspective. The first thing is to find the permissible working space by pushing the camera as far back as it will conveniently go, and measuring the distance from lens-board and sitter. The next thing is to find the degree of reduction. This we do by dividing the height of the sitter by the height of image required on the plate. In the case of a 6-inch cabinet portrait, this degree of reduction will be about 12 for a full-length 6-foot figure: Say, 6 for a half-length or bust, and 3 for a head. Then, to find the greatest focal length which can be used, divide the working distance by the reduc-

tion. The result is rather greater than it should be, because we have not allowed for the one focal length immediately in front of the lens. But it is a quite sufficient guide. Example: For a 6-inch image from an average standing figure, i. e., degree of reduction 12, working space 15 ft., focal length is $15 \div 12 = 1\frac{3}{12}$ ft.$=$ 15 inches. Try 14 inches and calculate back the other way: Space required$= 14 + (14 \times 12)$ inches$= 182$ inches $= 15$ feet 2 inches, so that 14 inches is just about the ongest focus which can be used.

In the same way we can calculate the length of studio for any given class of work with a given lens. Example: Carte (3-inch) portraits of full length (6 feet) sitters with 12-inch lens. Reduction figure is $(6 \times 12) \div 3 = 24$. Therefore camera extension is $12 + (12 \div 24) = 12\frac{1}{2}$ inches. Distance from lens to sitter is $12 + (12 \times 24) = 25$ feet, say 26 feet in all, to which must be added a fair amount of working space behind the camera and for the background.

How Back Focus Serves A last reference to focal length, viz., to the conditions under which a difference between the focal length and the back focus of a lens will be of service. In the case of a reflex camera, a lens of back focus which is greater than the focal length is of advantage in permitting a shorter focus to be used than would otherwise be possible. Owing to the movement of the mirror in this type of camera, the lens cannot be brought nearer than a certain distance, otherwise the mirror fouls the lens tube. With some types of reflex cameras, this space is such that, with a normal lens a shorter focus than 6 inches cannot be used on a quarter-plate reflex. Some people prefer a lens of not more than 5 inches focus, and are therefore glad to use a lenses such as the "Aldis," the back focus of which is appreciably *longer* than the focal length.

On the other hand, the telephoto lens provides exactly the opposite facility, viz., great focal length with a *short* camera extension. The Ross "Telecentric" lenses, for example, allow of a focus being employed which is somewhere about double the extension of the camera.

Altering Focal Length

When one has only one or two lenses, it is often of advantage to increase or reduce the focal length, as can readily be done by combining the lens with another. To shorten the focus, a positive or converging lens, such as those we have been considering so far, is used. It adds its bending power to lens No. 1, and so brings rays to a focus at a lesser distance. To increase the focal length, a negative or diverging lens is used, i. e., one which causes parallel rays to diverge.

Supplementary Lenses

Such lenses, both positive and negative, are sold as supplementary lenses, under various trade names, as "Planiscopes," etc., and are of focal lengths chosen, as a rule, for altering the focus of lenses supplied with hand-cameras; but it is easy to lengthen or shorten focal length to any extent by using the very cheap circular spectacle glasses obtainable from large general opticians. The extra lens of suitable focal length is combined with our lens proper by fixing the former in the hood, or in an extra cardboard collar which can be slipped on the lens tube, or by some such means.

Rule for Combining Lenses

The rule for finding the focal length produced by combining two lenses in this way is: Multiply the focal lengths together and divide by the sum (of the two) less the distance apart. Thus 10-inch and 6-inch lenses, 1 inch apart, give a focal length of

$$\frac{10 \times 6}{16 - 1} = \frac{60}{15} = 4 \text{ inches}$$

This is a very rough rule, particularly when applied to combining a R R or other doublet lens with a single lens. Moreover, usually we want to use the rule the other way about, so to speak. We want to know what focus we must use to increase or reduce the focal length to a given amount. The rule then is: Multiply the focal length of your lens by the focal length required and divide by the original focal length less the final focal length. Thus, to reduce an 8-inch lens to 5 inches: $8 \times 5 \div (8-5) = 40 \div 3 = 13$ inches, near enough. If the lens is to be increased in focal length, the calculation is

the same, but a negative lens must be used. In the latter case (and also to a lesser degree in the former) much depends on the position of the added lens. Different positions have to be tried in order to get the best definition on the plate, and thus the rule is quite a rough guide, but some useful indication of what focal length to try at the start.

The Diaphragm

So far we have considered lenses only as regards their focal length, and have perhaps familiarized ourselves with the effect of focal length on the size of the image and, in conjunction with the size of the plate, on the drawing of the image.

Now we must examine the effect of the diaphragm in several practical directions, viz., in determining the "speed" of the lens, the depth of focus, distortion of straight lines in the subject, and the production of other defects such as flare-spot.

Speed of Lens

The amount of light which reaches the plate is conditioned, so far as the lens is concerned, by the size of the diaphragm *relatively to the focal length of the lens.* If the diameter of the diaphragm is one-fourth the focal length, that is a very rapid lens and is designated $f/4$. If the diaphragm divides 6 times unto the focal length the speed of the lens is called $f/6$; if 8 times, $f/8$; if 11 times $f/11$, and so on. These four figures represent the chief classes of lenses as regards speed at their largest aperture. Portrait lenses and large-aperture anastigmats have a speed of about $f/4$; other anastigmats, about $f/6$; R R lenses, $f/8$; and single (landscape) lenses, $f/11$. In addition, there are still cheaper single lenses, also wide-angle lenses, the maximum aperture of which is about $f/16$.

Relative Speeds

I think I can assume that most of my readers are familiar with this speed standard for lenses, as also with the relation between the different f/numbers as regards the exposure required, viz., that exposures need to be in proportion to the squares of the f/numbers. In other words, with $f/8$ the exposure, as compared with $f/4$, is $\frac{8 \times 8}{4 \times 4}$

or 4 times, not the simple $\frac{8}{4}$ proportion. Similarly, $f/16$ requires $\frac{16 \times 16}{4 \times 4}$ (= 16) times the exposure with f 4. To avoid this troublesome calculation, it is usual to make the stops of a lens run in a series, each of which requires double the exposure of that preceding, whilst many lenses in this country are marked on the "Uniform System," according to which $f/4$ is marked 1, and the other stops by numbers 2, 4, 8, etc., indicating the number of times of exposure compared with $f/4$. The following table shows the comparative numbers:

Equivalent f and Uniform System Numbers:

Relative Exposure Required ...	1	2	4	8	16	32	64	128
f/numbers	4	5.6	8	11.3	16	22.6	32	45.2
U. S. numbers ...	1	2	4	8	16	32	64	128

Where f/ Numbers Mislead

The f numbers marked on a lens diaphragm-scale do not indicate the speed in all circumstances. This is so only when the lens is being used at practically its normal extension, i. e., in focus on distant objects. If the lens is racked out much beyond this, the real number becomes greater than that marked on the mount in the proportion of the greater extension to the normal extension. Thus an $f/4$ lens of 6-inches focus if used, as when copying, at an extension of 9 inches, has a real f/number $\frac{4 \times 9}{6} = 6$, i. e., $f/6$, and the exposure required is then more than double. A more direct way of making this allowance in practical work is to increase the exposure in the porportion of the square of the greater extension; or, more conveniently, to use a table of exposures when copying on a reduced or enlarged scale, taking the exposure when copying same size as 1. Such a table is:

Scale of Reproduction—	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{4}$	Same size	$1\frac{1}{2}$	2	3	4	5	6	8
Relative Exposures—	$\frac{1}{3}$	$\frac{2}{5}$	$\frac{2}{5}$	$\frac{3}{5}$	$\frac{3}{4}$	1	$2\frac{1}{2}$	$1\frac{1}{4}$	4	6	9	12	20

To use it, the camera is fitted with a scale marked with the extension distances corresponding with the various degrees of reduction and enlargement, when using a particular lens. These extension distances can be readily calculated by the rule given in a previous paragraph, "Extra Focal Length."

Also the *f* number marked on the mount of an unsymmetrical doublet lens ceases to have any significance if one or other of the two halves of the lens is used alone. Usually the maker tells us the focal lengths of the separate components of a double lens. The *f* numbers are then found by dividing the diameter of the iris or diaphragm-opening in the various positions separately by the focal length.

Depth of Focus

As we have learned at the outset of this monograph, an object in front of the camera is brought to a focus at a point behind the lens which, for a lens of given focal length, is nearer to or farther from the lens according as the object is farther from or nearer to the camera. If there were no means of overcoming that essential defect of a lens, the making of sharply defined pictures of subjects other than perfectly flat ones would of course be an impossibility. We want "depth of focus" or, as it is better termed, "depth of field," that is to say the simultaneous sharp rendering of near and distant objects on the focusing screen, and the diaphragm is the means of securing this effect. A whole number of THE PHOTO-MINIATURE could be filled with a consideration of this subject of depth, which a mass of discussion and misconception has greatly obscured. I will try to deal with it in the fewest possible words, and as closely as may be in respect to practical work.

Diaphragm and Depth of Field

The basis of depth of field is that the cone of rays forming the image of some one point in the subject has for its base the diameter of the diaphragm and, for its apex, the image point on the focusing screen. For practical purposes that image-point is sufficiently small if it is a disc ("disc of confusion") of diameter from 1-100 to 1–300 of an inch. In other words, we get the impression of a continuous sharp

picture if the whole image is made up of tiny discs, and we can reduce the optical image to a structure of this kind by reducing the size of the diaphragm.

The effect of a small diaphragm, if you will think it out with the aid of one or two diagrams, is to reduce the base of the cone of rays from each point in the subject, and so to narrow the angle of the cone. Thus, in an average position, the focusing screen receives on itself a series of image-discs corresponding with near and distant objects, which image-discs can all fall within a prescribed standard of size if the diaphragm be made small enough. In other words, a narrow-angled cone of rays from diaphragm to plate means depth of field, and for that reason it is argued that depth of field depends solely on the absolute diameter of the diaphragm; in other words, that a ½-inch diaphragm gives the same amount of depth whether fitted to a 3-inch or a 12-inch lens.

And it is quite fair to take this view if it is admitted that we can be content with an inferior standard of definition in a large print as compared with a small one. The reason assigned for this permissible difference is that a large print is looked at farther from the eye, and therefore does not demand the same degree of sharpness as a small one; it looks as sharp when held at the conveniently greater distance. The advocates of this theory of depth tell us that the small print made with a 3-inch lens is (or should be) looked at 3 inches from the eye, whilst the usually larger print for which a 12-inch lens is used is viewed at 12 inches distance.

Against all this is the fact that all prints up to, say 8 × 10 inches, are looked at about the same distance of 10 inches away, or are even examined more closely; and therefore it is necessary to take into account not only the size of the diaphragm, but the focal length of the lens. Thus, when our aim is an equal degree of definition in prints, large and small, focal length steps in as a factor. It becomes necessary to use a smaller diaphragm, the greater the focal length. Students find depth difficult to understand until they realize that its rules and formulas do not represent actual laws of nature, but are only conventions of service in guiding

us to some particular kind of result. They differ from the optical rules we have so far been considering very much as a cook's recipe for a pudding differs from the formula of a true chemical compound. The one can be varied at discretion; the other is part of the system of nature and therefore unalterable.

Depth Facts

Still a few broad facts in regard to depth may be stated as following from the general rule that depth is conditioned by the size of the diaphragm. It will be clear to us that great depth is not inconsistent with high speed (i. e., large relative aperture) of a lens. It all depends on the focal length we are using. The diaphragm of an $f/4.5$ lens of 3-inch focus, such as is fitted to a vest-pocket camera, is quite small, and gives great depth at the same time as speed; the same size of diaphragm in a 12-inch lens will also give considerable depth, but the speed of the lens will be only a sixteenth, something like $f/16$, instead of $f/4.5$. That very practical fact was recognized many years ago by the late Piazzi Smyth, whose prophecy of an all-in-focus but non-focusing camera at pill-box size has been realized to a large extent in the vest-pocket cameras of today. No. 125 of The Photo-Miniature on these cameras has given a remarkable proof of the great depth of focus possessed by such lenses, and the optical side of this question is fully discussed therein.

A further practical outcome from our diaphragm theory of depth is the very limited use of a long-focus large-aperture lens. Such a lens must necessarily have a large diaphragm, and therefore very small depth. While it is useful when the subject is all at a considerable distance, as in photographing a distant monument, obtaining large-scale pictures of animals, etc., for ordinary work it is impossible to obtain foreground and distance in focus without much stopping down. Hence, with lenses of focus 12 inches and upward, it is often a pure waste of money to buy one of $f/4.5$ aperture. The largest aperture which can be used in such cases is usually $f/8$, often much smaller, and an $f/8$ lens will be a third or a quarter the price.

Depth Calculations

It would lead us too far to attempt to deal with all the calculations of which depth of field is susceptible. Moreover it would be an unprofitable task, for the practical utility of such calculations is greatly diminished by the fact that they leave out of account the widely different properties of actual lenses. Lenses have not the perfectly flat field and the absolute freedom from faults which these depth formulas assume.

On the contrary, the field of a lens is often saucer-shaped; even that of an anastigmat has its shallow mounds and depressions, and often the quality of the definition is inferior toward the margins. As we use actual lenses and form our pictures all over the plate, most depth calculations are too far removed from practical conditions to be of any service.

Hyperfocal Distance

But there is one figure indicating depth which it is useful to be able to calculate, since it is of some service in hand-camera photography, or in designing any camera for focusing by scale. Suppose that with a lens of given focal length, say 4 inches, used with a given relative aperture, say *f*/15, you focus sharply on the extreme distance, i. e., on some object sending parallel rays, what is the distance of the nearest object which will be rendered according to some standard of sharpness, say 1-100 of an inch? This distance is the "hyperfocal distance." It is the distance beyond which all is in focus when the lens is focused on infinity. The formula for it can be easily shown from first principles to be

$$\frac{\text{focal length} \times \text{diameter of stop}}{\text{diameter of disc of confusion}}$$

This can be converted into a handier form by remembering that the diameter of a stop is equal to the focal length of the lens divided by the *f*/number. The formula thus becomes

$$\frac{\text{focal length} \times \text{focal length}}{\text{working } f/\text{number} \times \text{diameter of disc of confusion}}$$

Taking 1-100 of an inch as the standard of sharpness or permissible disc of confusion, our example is

$$\frac{4 \times 4}{16 \times \frac{1}{100}} = 100 \text{ inches} = 8 \text{ feet } 4 \text{ inches.}$$

This formula shows us that the hyper-focal distance is greater, the longer the focus of a lens; and becomes smaller as the lens is stopped down. With a 5-inch lens at $f/8$, it is 26 feet; with the same lens at $f/16$, 13 feet; with the same lens at $f/5.6$, 36 feet, and so on.

Fixed Focus

This leads me to that queer expression which has become current, viz., "fixed focus." I don't know who coined it; probably some adroit maker of cameras who desired to lead the public to think there was some special merit in a camera without a focusing movement. "Fixed focus" simply means the use of a diaphragm of small diameter, so that great depth of focus is obtained. Usually it is a diaphragm of less than half an inch diameter, with which fairly sharp images of objects both quite distant and near are obtained. The worst of it is that such a diaphragm means a poor speed of lens unless the latter is of very short focus. A half-inch diaphragm, with a 3-inch lens, is about $f/6$, which is fairly fast; but it is only $f/10$ with a 5-inch lens, and with many fixed-focus cameras a still smaller diaphragm is chosen, in order to improve the covering power. In other words, fixed focus is a good system for lenses up to 4 inches focal length, but a poor substitute for a focusing scale with focal lengths much over that. Calculation of the hyperfocal distance (from focal length and f/number as shown above) will give an idea of the nearness to the camera which objects can have without coming out unsharp in the negatives, made in a fixed-focus camera.

Selective Focusing

And here I must say a word connected with depth of focus which is of practical significance, though only indirectly applying to the lens. It is simply to remind the reader of the valuable aid which the adjustment of the camera-back affords in securing uniformly sharp focus of both

near and distant objects even without stopping down. By tilting the plate forward or backward (swing back), or by placing it obliquely to the straight line through the center of the lens (side swing), it is possible with very many subjects to obtain sharp focus of planes of the subject which are at very different distances from the camera. The ease with which this can be done depends on the grouping of such planes in the subject. An example will explain what I mean. Imagine we are photographing a somewhat distant house from a point of view immediately behind a flower-bed in the garden. The details of plants will be greatly out of focus if focus is obtained on the house. But, if the upper part of the plate be caused to recede from the lens by swinging the back in this direction, the immediate foreground will come into sharp focus with comparatively little stopping down. The expedient may be applied in endless ways and is often of the greatest service when the movement of the subject by wind or from figures in it makes it necessary to use as large a stop as possible.

Distortion of the Diaphragm

There is a third effect of the diaphragm which is of much smaller importance, since it is produced only with a single lens. With such landscape lens, the diaphragm is usually in front, and cuts off the rays coming from the subject at various angles in a way which causes the edges of the image to be formed by the edges of the lens, and the center of the image by the center of the lens. Thus a straight line near the margin of the picture is bowed inward at each end, acquiring a barrel outline. If the line falls in the middle of the image, i. e., opposite the center of the lens, there is none of this effect; the bowing becomes more pronounced as the margins of the field are used. This distortion, when full on the margin of the field of a properly designed landscape lens, is not great; it amounts to a bowing in at each end of a 6-inch line in the negative of less than $\frac{1}{16}$ of an inch; though that is quite enough to show plainly in the case of a subject like the straight edge of a house-side.

It means that a single lens is not suitable for subjects containing straight lines when those lines fall

near the edge of the plate. That, however, is not to bar single lenses even for straight-line subjects. Such a lens is quite good if you are careful to use one of long focus in relation to the plate, e. g., a 14- or 16-inch lens on a 4 x 5 plate, and to keep the lens fairly opposite the center of the plate. You then use only the central part of the field. These single lenses are such admirable instruments (on account of the brilliancy of the image), and are now sold second-hand at such low figures, that it is worth while bearing them in mind for work which does not call for a larger aperture than $f/11$.

If the diaphragm is behind the lens, the distortion is opposite in kind, i. e., pushed out at the ends of a marginal line in pincushion shape. Hence the doublet or rectilinear lens, in which the barrel distortion of the back component and the pincushion distortion of the front lens are simultaneously neutralized by the diaphragm placed between the two glasses. It doesn't follow that every doublet lens is altogether free from this line-bowing. The optician endeavors to make it so, and with most R R's such distortion is practically nil.

Flare-Spot This defect or aberration may take several forms, usually either a hazy patch of fog in the center of the negative or a less clearly defined patch or ring, occurring on the side of the plate opposite to the image of some light object. As a rule, the flare spot is an image of the diaphragm-aperture, due to light-rays reflected from some surface of the lens, and is a result of the diaphragm in the sense that adjustment of the position of the diaphragm will usually remove it. The precise cause of flare is a complex subject, and it would take us too far to explore it fully. We must be content to describe a test by which it can be readily detected. Place the lens centrally on the camera front and, in a dark room, focus sharply on an electric-lamp filament or gas mantle about ten feet away, using a diaphragm or stop about $f/16$. If there is flare, a halo will be seen around the image of the bright object in the center of the screen. If then the camera be turned slightly, the halo will move to one side of the center, as the image

moves to the other. A smaller stop will reduce the general illumination on the plate, whilst the flare-spot retains its original intensity and so appears more pronounced. This is a delicate test for flare, and one need not condemn a lens which shows slight flare under it. With single or R R lenses, the flare can be removed, in some cases by screwing out the lens (or lenses) in its (or their) tube; in others by shortening the lens tube. Anastigmats, as a rule, cannot be tampered with in this way. In either case, the mechanical work is of a kind which calls for an optician.

The Field of a Lens

So far we have been considering properties which, broadly, are common to all lenses good or bad. It is when we come to the field of a lens, i. e., the full area covered by the image, that we have to draw distinctions, and, in doing this to consider the field in two or, say, three respects. These are covering power or area of field in regard to focal length and speed, flatness of field, and fineness of definition.

Covering Power

The field of a lens is circular, and is limited by the construction of the lens itself and, sometimes, by the form of the tube or shutter in which the lens is mounted. Most of us use a camera the plate of which is fully covered by the lens, and so do not learn much about the covering power of the lens, as we should do by trying the lens on a much larger camera. Then, we should see, perhaps, that the lens covers barely more than the plate it is tested for. Beyond the circle within which that plate just falls, the definition falls off or ceases altogether, the focusing screen appearing dark.

In the latter case, the lens does not illuminate the larger area. On the other hand, another lens will cover a much larger disc than that including the plate without the image showing signs of fuzziness or "woolly" definition toward the margins. Some lenses, such as many R R's and anastigmats, will cover a much larger disc by using a smaller stop; with others, such as the portrait type, hardly any increase of covering power is obtained by stopping down. Usually a lens which is made to work at a large aperture ($f/4.5$) has

not such good extra covering when stopped down to $f/6$ or $f/8$ as has a lens of the same class with $f/6$ or $f/8$ as its maximum aperture. The optician generally has to sacrifice something to get the normal covering power at the large aperture.

Normal and Extra Covering Power

Extra covering power may be a necessity or a positive drawback, according to circumstances. Apart from covering the plate when the lens is central, we often need to cover it just as well when the lens is raised on its board, and hence require the greatest covering power, often at the largest aperture practicable.

But it must be remembered that a lens of this large covering power has its power *all the time*, and if a large plate is not presented to it, the margins of its field fall upon and light up the inside of the camera. Some of that light is scattered on to the plate, and tends to veil the negative. Hence, with a camera without much use of front, such as many focal-plane types, great covering power of the lens is no advantage, but the reverse to an appreciable extent. By trying a lens on a big camera, it is easy to see at a glance what its field is like. It is on account of this scatter of light from even the blackest of camera interiors that a lens the field of which falls sharply off altogether, such as a portrait lens and some anastigmats, is preferred for copying drawings, etc., where veiling is badly felt. A camera several sizes larger than that for the plate serves the same purpose, the whole image then falling at the end facing the lens without reflection of light.

Flatness of Field

Equally, lenses differ in the degree to which the image of a flat object coincides with the flat focusing screen or plate. It is in this respect that the anastigmats are markedly superior to the old R R's and single lenses, the fields of which, over which sharp definition of a flat object are obtained, are not flat but saucer-shaped, with the concave side toward the lens. For plan-copying and such work the anastigmat is certainly much the better instrument, yet not to the extent it might be thought, since copyists can just as conveniently use a

long-focus R R lens, utilizing only the central flat part of the field. On the other hand, there are plenty of subjects for which a lens with a concave field is really better than one with a flat field. A portrait photographer who knows what the curvature of the field of his lens is like can often turn it to advantage, and get near or distant parts sharp whilst using a larger aperture. The reason is that, in order to form a sharp image on the focusing screen, the rays from the nearer foreground part of the subject, such as knees or arms, meet not in the true field of the lens (for a flat subject), but a little way behind it.

Fineness of Definition

It is difficult to say much of practical utility on this property of a lens, important as it is in determining the "quality" of an objective. It signifies the ability of the lens to give a brilliant image of the utmost sharpness on the focusing screen and in the plate. It depends on the degree to which the optician, by his choice of glasses and curves, succeeds in eliminating the various aberrations from which a simple lens of one piece of glass greatly suffers. Those aberrations arise from distinct causes, so that the reduction of one often involves the increase of another.

The science of the optician, as embodied with such success in the modern lenses, consists in getting rid of all these aberrations at once over a considerable and flat field, and at the same time retaining a large working aperture. That is what is done in many *f*/4.5 anastigmats. It is done to a supreme degree by the portrait lens over its narrow angle of field. In lenses of smaller aperture (*f*/8 to *f*/16) the problem to be solved by the optician is simpler, and a small stop of *f* 32 removes most of the faults to which a lens is liable. It would be easy to fill pages on the separate effects of these faults, but the really important thing is to be able to make a test to show the performance of a lens in practice as regard rendering fine definition over a given area. To do this, as good a plan as any is to place quite square with the lens, and some 15 or 20 focal lengths away, a sheet of small-type printed matter of size sufficient to fill the plate with its detail. Focus

with the utmost care (with a magnifier) in the center of the plate, and make a negative on a slow, fine-grained landscape or transparency plate. The negative, examined with a magnifier, will show where definition begins to fall off toward the outside edges of the plate. Though not in any sense a scientific test, it does give a fairly good idea of what the lens will do.

It may be helpful to the novice if we briefly consider the principal defects or aberrations which the lens-maker has to correct before the objective will measure up to the standard required for photographic use.

Spherical Aberration

Spherical aberration, so called because it proceeds from the form or shape of the lens, is positive or negative in character according to the shape of the lens. In a photographic (convergent) lens, it is defined as the inability of the lens to bring to a precise point both the central and marginal rays of the same pencil of light. Properly speaking, the term refers only to direct rays—those which form the central portion of the picture-image. When oblique rays are considered, the error is known as zonal aberration, or coma. In all its forms it results in indistinct, diffused image points—really discs instead of precise points. Sharp definition is impossible with a lens in which this error has not been corrected at least in some measure. This is usually effected by combining positive and negative lenses of such refractive powers that the error of the negative lens counterbalances the opposite error of the positive. The amount of spherical error remaining in a lens which has been partially corrected in this way can be further reduced by placing in front of the lens a "stop" or diaphragm with an aperture smaller than the full diameter of the lens itself, thus cutting off the marginal rays which cause the trouble, and permitting only the central or direct axial rays to pass to the image field. This, of course, means that we are using only part of the light reaching the first surface of the lens in the formation of the image, with a consequent loss of rapidity. Thus the single lenses supplied in the cheaper sorts of hand-cameras are only roughly corrected for spherical and

other errors, their defining capacity depending on the use of diaphragms with small apertures.

Chromatic Aberration

Chromatic aberration is the inability of the lens to converge a ray of white light reflected from a luminous point to a corresponding point of white light in the image, due to the dispersion or separation by the lens of the several color-rays making up the white ray. This dispersion of the color-rays causes them, when converged, to meet at different distances from the lens instead of in a precise point. The error is corrected by combining positive and negative lenses of different dispersive powers, so that the negative aberration of the one destroys the positive aberration of the other. All photographic lenses are corrected so that the yellow (visual) and blue-violet (chemical) rays will meet in a precise point. Lenses thus corrected for two colors are described as achromatic; when corrected for three or more colors, as is necessary in three-color and reproduction work, they are described as apochromatic. A lens which is corrected for spherical and chromatic aberration is said to be *aplanatic*, a term now rarely used.

Curvature of Field

Hitherto we have assumed that the lens brings its image to a focus in a plane, such as the ground-glass focusing screen or sensitive plate. As a matter of fact, however, the focal surface is a curved field instead of a plane, so that to obtain a sharply defined image of a flat object, such as a series of circles drawn upon a wall or any other flat design, the sensitive plate should be concave or saucer-shaped in form. This inability of the lens to give a sharply defined image on a flat field is due to the aberration of form known as curvature of field. All lenses except anastigmats have this error. Its correction is important in lenses used in copying or in photographing objects in low relief, or groups where the figures are arranged in straight lines. It can be reduced by the use of a diaphragm with a small aperture or by combining a slightly concave (divergent) lens with the positive. The best anastigmats are quite free from this error, and so are described as possessing "a perfectly flat field," for which reason these lenses are preferred for copying.

Distortion The aberration known as curvilinear or marginal distortion is due to the varying thicknesses of the lens, and expresses ts inability to reproduce straight lines in the object as straight lines in the image. It exists in all single lenses with two or three exceptions, the kind of distortion varying according to the position of the stop or diaphragm. When the diaphragm is fixed in front of the ens the distortion is "barrel-shaped," so that marginal ines are represented as curved outward at the middle. With the diaphragm behind the lens the distortion is of the "pin-cushion" shape, marginal lines appearing as curved in the middle. This defect renders the single ens useless for architectural or other work where straight lines play a prominent part. It is corrected by combining two lenses with similar but opposite errors and placing the stop or diaphragm midway between them, so that the distortion produced by the one is corrected by the opposite distortion of the other. Lenses so corrected to reproduce straight lines as straight lines are known as "rectilinear" or "doublet" or orthoscopic lenses.

Astigmatism Astigmatism is the most widely advertised and least clearly understood of lens aberrations. It expresses the nability of the lens to give at or near the margins of the ield an image of an object containing vertical and horizontal lines in which both lines are sharply defined at the same time. It refers only to the bundles of rays which pass through the lens obliquely to its axis and affects the marginal definition of the picture-image. Thus, where this error exists in a lens, the image-bearing rays reaching the lens obliquely are converged to two blurred ines at right angles to each other instead of a precise point. For example: If we set up a card inscribed with a boldly printed plus sign and attempt to focus the sign with a lens in which this error has not been corrected, we may get both vertical and horizontal lines sharply defined at the same time in the center of the screen; but as we move the camera so that the image travels from the center to the edges of the screen, one or other of the lines will assume a blurred ellipsoidal form. Hence

the practical result of astigmatism in a lens is a lack of sharp definition in the marginal portions of the photograph, which destroys the usefulness of the lens for architectural photography, copying or other branches of work where critical definition over the whole field combined with rapidity are essential to success. The correction of astigmatism is effected by ingenious combinations of various kinds of glass possessing different powers of refraction and dispersion, and arrangements of curves and thicknesses made possible by the many varieties of optical glass placed at the service of lens-makers by the researches of Abbe and Schott, at Jena, during the early eighties. Lenses in which this error is corrected, and which are therefore capable of reproducing marginal points in an object as points in the image, are called anastigmats, orthostigmats, verastigmats, plastigmats, or simply stigmats, the basic word *stigma* meaning "a point," *astigmatic* meaning "without a point," and *anastigmat* meaning "back again to a point." Apart from this real significance, however, an anastigmat is generally understood to mean a lens in which all the five or six principal errors or aberrations are largely or wholly corrected, so that it will give a sharply defined image with a flat field within a comparatively large angle when used at a large aperture. Thus the correction of astigmatism is seen to be a great advance in the attempt to combine defining power and rapidity in the lens.

Lenses Classified

Turning now to the trade catalogues, we find lenses described under many different names, and the prices seem to differ as variously as the names. Let us classify them according to their capacities.

Single Lenses

I: Single lenses, otherwise called single achromatic, meniscus, achromatic meniscus lenses, are nowadays usually sold as irremovable parts of the inexpensive hand-cameras to which they are fitted. They are also sold separately, for use in combination with other lenses, as "supplementary" lenses under various trade names, as already mentioned in an earlier paragraph on "Supplementary Lenses." They are made up of two

simple positive and negative lenses cemented together, chromatic and spherical aberration being thus at least partially corrected. With this correction and the further help of the small diaphragm apertures with which they are fitted, these single lenses are capable of very good work within a limited scope. The necessary use of small apertures, rarely larger than *f*/16—one-sixteenth of the focal length of the lens—makes them slow, so that successful work with them depends upon favorable conditions, such as fairly distant subjects, sunlight days out-of-doors, or subjects without movement such as landscapes, where critical definition over the whole field is not necessary, etc. Similarly, since single lenses are not corrected for distortion, they cannot be used in photographing buildings, copying, or subjects with prominent lines near the margins of the field, as such lines will be represented as curved in the picture. Apart from these disadvantages, the single lens properly understood and used with discretion has its peculiar good points for certain kinds of work, such as pictorial landscape, wherein its "depth" (due to its small aperture) and softly diffused definition (due to the amount of spherical aberration left uncorrected) are especially desirable. The really excellent work produced with the cheap hand-cameras fitted with these single lenses offers further proof of their usefulness. For purely pictorial work the single lens will give results wholly pleasing.

Commercial Supplementary Lenses

The single lenses sold as "supplementary" lenses are simply achromatic positive or negative elements of different focal lengths, which, when used with the lens already fitted to the camera, diminish or increase the focus of the original lens, and so enable the user to get larger images of distant objects, or to photograph objects nearer to the camera than was possible before, or add to the covering power of the lens so that it will cover a larger plate as a "wide-angle" lens. These "supplementary" lenses come in "sets," each lens being marked with its proper use, so that no abstruse calculations are needed. In Europe the use of simple, non-achromatic spectacle lenses as "supple-

mentary" lenses or "magnifiers" is more common than on this side of the Atlantic. They offer a wider range of possibilities than the "cut-and-dried" sets, but require individual calculation in their adaptation for practical use.

Single Anastigmats

Mention should be made here of the fact that the introduction of new kinds of Jena glass has made possible the construction of single lenses practically rectilinear and anastigmatically corrected to give sharply defined images over a flat field with the comparatively large aperture of *f*/12. These remarkable lenses, of which the Zeiss Series VII is perhaps the best known example, have been evolved in the construction of the Convertible Anastigmats introduced by Zeiss under the name Double Protar VIIa. See further in the paragraph under "Anastigmats."

Rectilinears

II: Rectilinear lenses, formerly known as "doublets," but also variously described as rapid rectilinears, symmetricals, double symmetricals, aplanatic, convertible, rectigraphic or tri-focal lenses, according to their make-up, are usually composed of two single lenses mounted in a tube at some little distance apart with the diaphragm or stop midway between them. This construction permits the elimination of the error of distortion and the better correction of spherical aberration, also allowing the use of larger diaphragm apertures, so that the rectilinear represents an advance over the single lens in defining power and rapidity. Thus the average rectilinear is usually listed to cover the plate for which it is made at *f*/8, theoretically four times as rapid as the single lens at *f*/16, but practically eight times more rapid, since the latter would have to be "stopped down" to *f*/22 to define the image equally well over the same area. Until the advent of Jena glass and the anastigmat, the rectilinear represented the highest achievement among lenses for general uses, and it is still quite good enough for 80 per cent of the work of the photographer, provided that he does not want to attempt high-speed work, three-color or fine reproduction or scientific photography.

Symmetricals When composed of two single lenses of approximately the same focal length, the rectilinear is known as symmetrical and combines two lenses,—the double objective (or lens used as a whole) and the rear element used alone as a single lens, in which case the single element will have twice the focal length of the doublet or whole lens. When a single element of an objective is used in this way, its rapidity is diminished by the necessity for the use of smaller diaphragm apertures—about which see the earlier paragraphs on the use of the diaphragm.

Convertible: Tri-focal Rectilinears made up of single lenses of different focal lengths are sometimes spoken of as unsymmetrical doublets. When these are so constructed that the single elements can be used separately, we have what is known as a convertible or three-focus or "tri-focal" lens. This simply means that the objective is made up of two corrected lenses of different focal lengths, either of which may be used as a separate lens, so that the objective embodies three lenses and a choice of three different focal lengths. The Ilex Rapid Convertible is a favorable example of this class of lenses.

Lens Sets This evolution of the tri-focal or convertible lens led to the introduction of "lens sets." These usually comprise a tube or exposure shutter with from three to seven achromatic elements which, by various combinations, according to directions accompanying the "set," provide from six to fifteen different lenses adapted for various purposes. In the cheaper "sets" the correction of the lenses is indifferent, so that the various combinations are slow and give soft rather than sharply defined images. The Anastigmat "sets," however, are more carefully corrected and give results which justify the higher prices asked for them. To sum up, then, for all ordinary purposes where critical definition from the center to the edges of the plate and rapidity are not essential, the rectilinear of today, with a rapidity expressed by an aperture of $f/8$, is as good a lens as the amateur can desire. In every-day work out-of-doors or indoors, its lack of complete correction will

often prove advantageous, giving softer definition at the edges of the picture-image, a better separation of the planes of the picture field and greater "depth."

On the other hand, when subjects including rapid movement are in question, as in focal-plane photography, or where we may be required to get good negatives of difficult subjects on dull days under unfavorable conditions of illumination, for portraiture indoors, nature subjects, animal photography, three-color reproduction and scientific work of all kinds, we can best ensure success by using a lens which by its more perfect correction will give us every possible advantage in defining power and rapidity. This we have in the anastigmat, which, plainly put, is simply the highest type of the rectilinear at present available.

Anastigmats

III: Anastigmats differ in form and name so variously with each maker that it is difficult to group or classify them in any way which will help us in an intelligent estimate of their qualities. This is best accounted for by the fact that the many varieties of optical glass now available provide many different ways of attaining the same end. The result of this was seen as soon as the first anastigmats were introduced; other opticians quickly perceived that the new glasses offered other ways of attaining the same superior correction, and soon after there were as many different anastigmats as there were different makers. The same procedure followed the introduction of each new form of anastigmat by any maker, and this duplication has been further stimulated by competition, so that today the photographer is fairly bewildered by the variety of anastigmats from which he has to make choice for his purpose.

Points of Choice

Taking them, for the moment, as equal in general excellence (which they are not), the following three points are worthy of note in the choice of a particular lens from the many offered in the trade catalogues: (1) Covering power: In some anastigmats this decreases when the diaphragm is changed to a small aperture. This is not desirable. With many subjects it is desirable to be able to focus with a large aperture and then use a smaller

aperture to get more "depth" or to regulate the exposure. (2) Initial rapidity: Other things being equal, it is better to choose a lens which will work at *f*/5.6 than as *f*/7 or *f*/8, simply because the first is twice as rapid as the last, requiring only half the exposure. (3) Some anastigmats can be used only in their complete form; others are convertible, i. e., their elements can be used separately, this affording two or three lenses of different focal lengths according to whether the complete lens is symmetrical or unsymmetrical in character. Other things being equal, and more especially if there is no sacrifice in the rapidity of the complete lens, the unsymmetrical convertible form offers the widest possibilities of usefulness. Another point, already mentioned, should not be overlooked, viz., that of two lenses equal in rapidity and defining power, the one which defines the larger angle (greater width of image) is the better one. Apart from these general points, with anastigmats as with other lenses, the choice of a lens depends most largely upon the work for which it is required. From all that has been said, the reader will have grasped the fact that no one lens can do all things equally well and that every lens represents a compromise.

Universal Lenses

Lenses in the make-up of which special or particular abilities have been in some measure sacrificed to secure general all-round capacity are sometimes catalogued as "universal" lenses. The Goerz Dagor (Series III, *f*/6.8), the Collinear (Series III, *f*/6.8), the Ilex Anastigmat *f*/6.3; the Ross Combinable Lens; and the Bausch & Lomb-Zeiss Tessar Ic *f*/4.5 belong to this class. All these offer a remarkable range of usefulness and leave little to be desired for all-round, every-day work with the hand- or stand-camera. Where price is not considered, however, the convertible anastigmat is undoubtedly the highest type of "universal" lens, since, by having three or four elements of different focal lengths, we can ourselves make up an objective to meet almost any possible requirement. The Zeiss Protar Series VIIa is a good example of this "convertible" class.

Special Lenses

Coming now to special lenses, we find in the catalogues mention made of wide-angle, portrait, telephotographic and process lenses. When properly listed under these names, these lenses are designed for special branches of work, and it may be assumed, as a general thing, that some other quality has been sacrificed where necessary, to give the lens special ability in its particular field. The wide-angle lens has already been mentioned in earlier pages. Process lenses do not come within the scope of this monograph, and so will be passed over without detailed consideration.

Portrait Lenses

Lenses especially designed for portraiture belong to a special class. In the construction of such lenses, everything is sacrificed to secure great rapidity with sharp definition within a very limited field. Thus we have portrait lenses listed as working at apertures of *f*/2.2, *f*/4, *f*/5, *f*/6; a lens working at *f*/2 being four times as fast as one working at *f*/4, six times as fast as an *f*/5, and nine times as fast as an *f*/6. Such lenses necessarily have very little depth of definition when used at full aperture and, when smaller diaphragm apertures are used to give greater depth, the loss of rapidity is generally accompanied by other disadvantages. The field of a portrait lens is extremely curved, and its defining power fails rapidly from the center of the field. For these and other reasons, such as its limited usefulness and great cost, the special portrait lens is rapidly being displaced by the anastigmat, which will do equally well all that the specially designed portrait lens can do and has a much wider field of usefulness, because of its better correction. Of anastigmat portrait lenses the Zeiss Portrait Unar, Series Ib, is a notable example, combining the good qualities of the anastigmat with the ability to secure softness, roundness and gradation, these latter being controlled by an adjustment fitted to the front lens by which its elements may be separated or brought closer together at will, this adjustment permitting any amount of diffusion of definition desired. The Heliar, the Goerz Celor, and the Bausch & Lomb Portrait Unar, and the Ross

Xpres also belong to this class. Among old-style portrait lenses, those of Dallmeyer, Ross, Bausch & Lomb and Voigtlander still retain their preëminence, although of late years the market has been flooded with less expensive lenses designed for portrait and group work. In purchasing a lens from this last class as a matter of economy, the buyer should satisfy himself by practical test that the lens has the qualities required for the work it is to do. Special Achromatic-Meniscus Portrait lenses for amateurs, giving softly diffused images, are offered by various makers, the Verito, Struss Pictorial lens and Pinkham and Smith Achromatic being familiar examples.

Telephoto Lenses

V: The telephotographic lens is an objective or lens system of somewhat complex construction, designed to give larger images of distant objects than can be obtained with an ordinary photographic lens. The peculiar properties which make it preëminent in this special branch of work also make it useful in animal photography, portraiture, and other special applications of photography. As a detailed explanation of the lens and its uses would fill a volume of goodly size, the reader desiring a comprehensive account of these is referred to such works as *Telephotography*, by Lan Davis; Wheeler's *Modern Telephotography* and Marriage's *Elementary Telephotography*, wherein the subject is dealt with at length. The following summary will probably suffice for many of my readers.

Size of Image

The size of the image of an object depends upon: (1) the distance of the object from the lens, and (2) the focal lengths of the lens used in making the photograph (which, roughly speaking, is the distance between the diaphragm of the lens and the focusing screen when a distant object is focused on the screen). We can therefore vary the size of the image, or scale of our reproduction of an object, either by photographing it from different distances, or by the use of lenses of different focal lengths. Where it is impossible, difficult or undesirable to alter the distance from which the object is to be photographed, then we can vary the size of the

image only by using lenses of different focal lengths. The rule here is that of an object at a given distance, the longer the focal lengths of the lens, the larger is the image obtained. And, of course, whatever the focal length of the lens, the bellows-extension capacity of the camera must be sufficient to allow of the separation of lens and plate necessary to give a properly focused image. So that the getting of large images of distant objects ordinarily involves the use of large, unwieldy lenses of great focal length and cameras with unusual bellows capacity.

Tele Combinations

The telephotographic lens system, made up of a combination in one tube of an ordinary photographic lens with a special negative (magnifying) lens, gives all the advantages of a long-focus lens without the need of a corresponding increase of bellows extension. Thus the telephotographic lens is lighter, less bulky and less costly than an ordinary lens of the same focal length and will give larger images of distant objects with small cameras with short bellows extension than can be obtained by any other method. Telephoto lenses are sold as complete instruments (an ordinary or positive objective combined with a negative element, mounted in a tube fitted with rack-and-pinion movement or in an adjustable tube permitting the required separation of the lenses); or simply in the form of telephoto attachments (an achromatic negative lens mounted in a tube with rack and pinion, the tube being threaded to receive an ordinary photographic lens). The latter form is generally preferred, as the attachment can be removed at will, leaving the positive lens unaltered for every-day work. The separation of the positive and negative elements by means of the rack-and-pinion movement varies the focal length of the system, so that the telephoto lens is really a long-focus lens of variable focal length. The degree of the magnification or enlargement of the image depends upon the separation of the two elements, the magnification being greater as the two elements are brought closer together. By various combinations of negative and positive elements of different focal lengths and suitable bellows extension, a telephoto

system is obtained, giving a definite range of magnifications according to the requirements of the individual worker. Tele-negative lenses or telephoto (complete) objectives are supplied by almost all the principal lens makers, the Bausch & Lomb Company and the Goerz Optical Co. offering inexpensive tele attachments specially designed for hand-camera work.

Choosing a Lens

With the information thus far given regarding the different types of lenses and the properties they possess, the reader should find little real difficulty in the selection of a lens to meet his individual requirements, or in the more intelligent use of such lenses as he may already possess. Of course, no one lens can be expected to do all kinds of things equally well. Different branches of photographic work call for different lens qualities, and, as we have seen, it is not possible to combine in one lens all the capacities needed for widely differing classes of subjects. A glance over these varying requirements in different branches of work may be useful.

Hand-Camera Lenses

For general hand-camera work the qualities chiefly required in the lens are defining power, covering power, depth of field and rapidity. Taking the last first, for all work where the exposures will range from $\frac{1}{5}$ to $\frac{1}{100}$ of a second, a lens working at *f*/11 will serve under favorable light conditions, but *f*/8 will give wider possibilities of success in dull weather, or with different classes of subjects, being sufficiently rapid to allow of movement in the view if this is not too rapid and the object not too near the camera. For subjects including rapid movement, or requiring exposures ranging from $\frac{1}{100}$ to $\frac{1}{1000}$ of a second or higher, an anastigmat working at *f*/6 should be chosen, but for the fastest instantaneous work, with focal-plane shutters, where every possible advantage must be had, then a lens working at *f*/5.6 or *f*/4.5 is preferable. Since depth of field is very desirable in hand-camera work and yet cannot be combined with rapidity, we can compromise to advantage by the choice of a lens combining great covering power with short focal length, remembering that a short-focus lens gives greater depth than another of the same rapidity

but longer focus. The short-focus lens will also give a wider view-angle, which is often desirable in hand-camera work. The focal lengths advised for hand-camera lenses are: for pictures 3¼ x 4¼, about 4½ inches; for 4 x 5, about 6 inches; for 5 x 7, 7½ inches. When pictorial photography, or figure or nature studies with the hand-camera are in question, however, these focal lengths will be too short to produce the most pleasing results, and lenses of greater focal length should be chosen. As mentioned on an earlier page, the best way to solve the hand-camera lens question is to know the extension capacity of the camera and then purchase that particular convertible two or three foci anastigmat which offers the largest possibilities in the way of different focal lengths and rapidities. If the limited extension of the camera does not permit this, then the special forms of anastigmats sold in cells ready for simple adjustment to the exposure shutter fitted to the camera offer a happy solution of the difficulty.

Outdoor Work

For outdoor photography of the average sort, which does not include rapidly moving objects or subjects requiring critical definition combined with rapidity, the rectilinear lens with a speed of *f*/8 has all the qualities needed for successful work. It shows its qualities best if stopped down to *f*/11 or *f*/16, and should not be used at its full aperture save under poor light conditions or when the subject includes movement. Correctly speaking, the rectilinear is inferior to the anastigmat only in its speed and marginal definition, the anastigmat being simply a more perfectly corrected rectilinear and not a separate or special type. Hence, where speed and marginal definition are not essential to success, the amateur can save money without sacrificing any desirable quality by buying a rectilinear and leaving the anastigmat for those who need the peculiar qualities in which it is supreme. The focal length of a rectilinear for general purposes should be about one-third longer than the longest way of the plate, but if much work is to be done in cities, where it is not always possible to get far enough from the subject, the focal length can be shorter, although it should always exceed the longest

dimension of the plate used. For commercial work, where definition is generally imperative and rapidity a desirable factor, the anastigmat is preferable to the rectilinear for reasons already made plain. For outdoor sports of all kinds, groups and similar subjects, also, the anastigmat, with its greater speed and better covering power, gives advantages which it would be folly to despise. In copying and enlarging, too, the anastigmat leads because of its superior defining power.

Interiors: Buildings

For interior work and architectural photography we want angle of view, covering power and freedom from distortion, rapidity being of lesser importance. The angle of view included by a lens, as we know, is determined by the focal length of the lens in relation to the base line of the plate used. The shorter the focal length of the lens, the larger is the angle of view it will give on a plate of given size. Hence, we use wide-angle lenses most largely in this class of work, where it is often impossible to get far enough from the subject to permit the use of a lens of normal focal length. Since, however, the use of too short focus lenses gives violet perspectives, this should be avoided and a lens of normal focal length employed wherever possible. Covering power is essential because this class of work often calls for the use of the rising and falling front, the swing-back, etc. Unless the lens is capable of covering a much larger plate than that used with it, this will result in dark corners and imperfect illumination.

With this our survey of the lens in action must be brought to an end. By the omission of diagrams and illustrations, I have compressed more lens facts into this little handbook than can be found in any work of similar scope, and the reader will, I trust, find most of his lens questions answered herein.

The New England Convention

The event of chief photographic importance since THE PHOTO-MINIATURE last appeared was the seventeenth annual convention of the Photographers' Association of New England, held at Boston, August 10, 11 and 12, under the presidency of Mr. J. P. Haley.

The New England Association embraces the photographers of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut and the Maritime Provinces. It has been fortunate in being officered by men as attractive in their personalities as they have been notable in the profession. And the members of the New England Association have the happy habit of coming back to their conventions with unfailing regularity, so that one meets the same faces year by year and the same delightful people.

The 1915 convention was remarkable for its infusion of new blood in the field of lecturers. There was an interesting illustrated talk on "Newspaper Photography," by A. J. Philpott, Art Editor of the *Boston Globe*. President Haley himself gave an illuminating demonstration of the making of artistic portraits—showing what to leave out. Prof. E. J. Wall, of Syracuse University, presented a lantern lecture on "Scientific Advances Made Possible by Photography." Mr. Dawes, of the Wollensak Optical Co., gave a talk on "Lenses." Dr. T. W. Smillie, of the Smithsonian Institution, sent his illustrated lecture on "The Progress of Photography from its Inception," illustrated with exhibits from the national collection at Washington, the lecture being delivered by Mr. W. H. Towles, president of the National Photographers' Association. Past-president John H. Garo held a big audience spell-

bound by his practical demonstration of "Posing in Portraiture." Mr. John I. Hoffman, the Secretary of the National Association, talked upon "Co-operation in Business;" and the writer of these notes had the privilege of half an hour's chat one afternoon on the "Possibilities of Photography in the Illustration of Newspapers, Magazines and Books."

Apart from these talks and the business sessions there was a very interesting exhibition of the work of the members of the Association, and a fairly representative showing of photographic specialties by many of the leading manufacturers and dealers. Taken altogether, the New England convention of 1915 was a model of what a convention should be. There was a free interchange of information, a practical discussion of everyday business topics and difficulties, and just the right amount of sociability to keep the crowd happy. I am publishing Professor Wall's lecture as an admirable summary of the field it covers.

SCIENTIFIC ADVANCES MADE POSSIBLE BY PHOTOGRAPHY

By PROF. E. J. WALL

Probably very few of you have realized how young photography is. As a matter of fact it is just seventy-six years ago, on August 14, 1839, that the first working description of Daguerre's process was published. Photography, as we know it today, is really only twenty-five years old. It is only within the last few years that it has been recognized as a science, hitherto it has been merely empirical or rule of thumb. A science it assuredly is, although most of you probably use it as a means for picture-making. The trouble is and has been that it is so easy to make a photograph that this has actually stood in the way of advancement of photography as a science.

The advances of late years are probably as well known to you as to me. The improvements in our sensitive surfaces, in our lenses, I need not dilate upon. That we have reached finality is, of course, an absurdity. As proof, I need only point to the discovery by the Jena Glass Works of the method of incorporating a large amount of fluorine in glass, which will have probably considerable influence on the future of lens-making. This is directly due to the application of scientific research, and it is only by the application of modern scientific research that further advances can be made. One of the most striking and hopeful signs is the enormous change in the theories of our various processes. To some, of course, theory is all rubbish, but it is out of theory that future advances will come.

Photography, in the widest sense of the word, is now of such universal application that very few people have any idea of its real usefulness. I propose to briefly sketch some of its uses.

In the domains of physics and chemistry important problems are being solved by the study of photographs of falling bodies, of the oscillations of the electric current. In this last case, whereas it would take a man some hours to trace the curves, we are now obtaining permanent records in a fraction of a second. It is probably in spectroscopic research that our science is of the most use. Photography has revolutionized the methods in this department of science. Whereas the visual method of wave-length measurement was a most laborious and time-consuming task, and the results were always open to question, we now take a negative and this is measured by any assistant. In all large steel works photographs of all alloy steels, etc., are made daily. Photography has here become as important as chemical analysis.

In the fields of astronomy and astrophysics our science has entirely replaced visual observation, and for two definite reasons:—the plate does not think and it never gets tired.

Because it does not think, it does not imagine that it sees things that are not, which is too often the fault of human observers. The latter also tire, whereas the

longer a plate looks, the more it sees, and, given accurate driving mechanism to the telescope, the exposures may be spread over several successive nights. You all know that the observatories all over the world are preparing an international star chart or photographic map which will serve for a permanent record for those who come after us. Photographs of nebulæ have revealed secrets that astronomers did not dream of.

Turning to more mundane affairs, the meteorologist uses photography for obtaining automatically thermometric and barometric changes; for recording the formation of clouds; of wave-forms; the tracks of windstorms and earth-tremors. The botanist has no longer to rely on drawings. It is no longer even necessary to dissect a plant to show its parts. By means of X-rays and the plate we can show the internal structure of the living plant. It has been proved by means of the plate that plants have eyes or lenses which condense the light on to the underlying tissue, and thus set in motion those photochemical processes which result in the formation of starch from its gaseous elements.

There is no kind of animal life that is not better portrayed by the camera than by the artist. Birds, beasts, fishes and insects are all made to sit and look pleasant. Distance is no longer an obstacle, thanks to the telephoto lens, nor is night a deterrent, thanks to flashlights fired by the animals themselves. The hunter armed with a camera is becoming as familiar as he with the repeating rifle.

Probably the most valuable application of our science lies in the amelioration of human suffering, the spreading of knowledge of the innermost structure of the human body and its appearance in disease. You have all heard of how a person was photographed in the ordinary way and blotches were seen on his forehead in the negative, although none could be seen visually, and how two or three days later he developed a loathsome disease. This story has been denied more than once, but it is an actual fact. As practical photographers, you know how the plate will accentuate freckles and other skin blemishes due to the peculiar color sensitiveness, or I should say, its color blindness.

In surgery the motion picture has become a most valuable means of education. It is no longer necessary for the surgeon, when operating, to be surrounded by students, nor for him to interrupt his work,—motion pictures of the operation can be taken and shown at any time.

It is not only the exterior of the body that can be photographed now. It is as easy to take the back of the eye as to take a snapshot in the street. I wonder how many of you will believe that lowering a camera into a person's stomach and taking a dozen pictures is almost as easy, if not easier, than taking a dozen portraits of the same person in the studio. Certainly in the former case the person cannot say that the portraits of his or her stomach are not true. In the second case he or she can say that the prints are not satisfactory, then the poor photographer suffers.

The application of photomicrography to the study of bacteria, both harmful and beneficial, that populate our systems is too well known to require more than mention; but probably the latest advance is in the obtaining of moving pictures of the war waged against the evil-working living bacteria by the beneficent leucocytes. The eating of a malevolent bacillus by a leucocyte has actually been photographed. It is impossible for me to remind you of all that our science has done in the field of medicine, but I ought not to omit the use of the X-rays. It is now generally admitted that these are merely vibrations or disturbances of extremely short wave-length, practically light which in consequence of our extremely limited powers we can neither see nor feel. You are all more or less familiar with the results. Since their discovery twenty years ago enormous advances have been made. In 1895 I had to give an exposure of ten minutes to obtain a radiograph of my hand. Today we can obtain a good radiograph of the heart in 1-3,000 second.

The applications of photography to land-surveys, either from earth-level or above it, are now reduced to practical methods. Nearly the whole of Canada has been photogrametrically surveyed. The Germans in particular have made extensive use of photography from

balloons and Zeppelins to record the surface of the earth. Two months ago there appeared in one of their technical journals some excellent photographs of the Russian lines in Galicia, and it was possible to clearly distinguish not only the advanced trenches, but also the second line of defence and even the holes made by the shells. Such photographs are of course of immense benefit to an attacking force. Every German officer is provided with minute photographs of the country he is expected to enter, and on these is clearly shown every hedge, house and road. The whole outfit, including an electric torch and an eye-piece, can be carried in the pocket. Every country is today using our science to study the flight of projectiles and their effect not only on the target but on the rifling of the gun-barrels.

Of the uses of photography in presswork and illustration I need not speak. You know as well as I do that photography has killed woodblock-making and steel engraving. Whether art is better for this is an open question, but it has been a potent factor in the dissemination of knowledge.

In ethnology and anthropology photography has entirely replaced the craftsman. The camera makes no mistake in drawing; it has no prejudices and for these reasons it is most invaluable to the explorer.

But it is in the cause of justice that photography has scored some of its greatest triumphs, nor is its use of recent date, for a burglar was caught in 1854 by means of a daguerreotype. Judicial photography can easily be divided into two parts: firstly, the recording in permanent form of that which can be seen, such as the appearance of a place of a murder, and secondly, that which we may call its detective power, or the bringing to view of detail which cannot be seen by the human eye. Probably the French have brought the first branch to the greatest perfection but the Swiss, under Professor Reiss, have evolved the detective powers of the camera to a perfection attained by no other country. Some of his work transcends the wildest dreams of Sherlock Holmes. Charred paper has been photographed under special lighting, special plates and filters, and writing on it deciphered. Lithographic

stones that had been carefully polished till they showed no trace of an image to the eye at once revealed marked signs of forgeries to the camera. Falsifications of documents are mere child's play to detect, and you all know the famous finger-print system of Bertillon now adopted by all civilized countries.

For the reproduction of documents, paintings and old manuscripts photography is of immense value, and many of the old palimpsests have been deciphered by its aid when they completely baffled the most expert paleontologist. Beyond these, we have the familiar achievements of photography in the transmission of pictures by wire, and the obtaining of pictures from life in colors, of which the examples I will show you are themselves the most convincing documents.

Notes and Comment

On Wednesday, July 21, Mr. John J. Bausch, president and founder of the Bausch & Lomb Optical Co., Rochester, N. Y., celebrated his eighty-fifth birthday. As a memorial of the happy day, the employees of the company presented Mr. Bausch with an album containing a salutation signed by every one of the 2,500 employees.

Mr. Bausch's response to this attribute of affection became known on the following Saturday when the employees received their pay envelopes. In each envelope was a card inscribed as follows: "On July 25, 1915, I will have reached the 85th anniversary of my birth, and being able to enjoy my work in daily association with my employees, I desire to give expresssion to my feelings of gratitude by contributing $10,000 to the Pension Fund, $10,000 to the Relief Fund, and by making Monday, July 26, a holiday with full pay.

Mr. Bausch finds much pleasure in referring back to the trials of the early years of the great business of which he is the head and moving spirit. Especially

does he love to speak of the devotion of his wife, the mother of the sons who are now active with their father in the work of the Bausch & Lomb Optical Co. May he have many more happy years with them all.

My readers will be interested to hear that the Ansco products were selected for the highest honors at the Panama-Pacific Exposition, despite the fact that the Ansco line was not entered in competition; in fact the line was not on exhibition when the judges met.

One of the judges who had attended the Photographic Expositions recently held in New York City, noticing that the Ansco line was incomplete, turned to the jury and remarked "Gentlemen, the Ansco Co., is making the finest small camera I have ever seen. In my opinion, it is the best camera of that particular style in the world. but since they have not seen fit to place it on exhibition, we cannot take it into consideration." For the exhibit of such Ansco goods as were accessible, however, the Ansco Co. was awarded the gold medal and also the medal of honor, the highest award for professional photographic goods. This award covered the New York studio outfit with Ansco studio upright stand, Ansco printing machines and professional Cyko paper. The gold medal was awarded to the Ansco amateur cameras, Ansco film, amateur grades of Cyko papers, Ansco and Cyko chemicals. The line of small cameras referred to by the juror in the preceding paragraph is that represented by the Ansco Vest-Pocket Series, which have many special features distinguishing them from all other vest-pocket instruments.

"The Secret of Exposure," 72 pages, illustrated. Paper, 25 cents; cloth, 50 cents.

"Beginners' Troubles," 72 pages. Paper, 25 cents; cloth, 50 cents.

These two handbooks are the first issues in a new series under the general title "Practical Photography," edited by Frank R. Fraprie, S.M., F.R.P.S., and pub-

lished by the American Photographic Publishing Co., Boston, Mass. I am informed that they are intended to replace the series of 10-cent handbooks formerly published by this firm, being, in fact, new editions of these useful little books, with considerable revision and addition. The first two numbers received are crowded with practical information on their respective subjects and are well worth the price asked for them.

The New York offices of Burke & James, Inc., Chicago, have been removed from the ninth to the tenth floor of the Brunswick Building at 225 Fifth Avenue. This removal gives Messrs. Burke & James four times their former space and enables them to carry a much larger and more varied stock of supplies for their eastern trade.

The new "Rexo Manual," just received from Burke & James, is a 48-page booklet, fully describing the different varieties of Rexo developing paper for contact printing and enlarging, amateur and professional grades, with many tested formulas for the manipulation of the paper, including formulas for obtaining sepia, green, blue and red tones. Copies of the "Rexo Manual" can be had for the asking from either the Chicago or New York branches of Burke & James, Inc.

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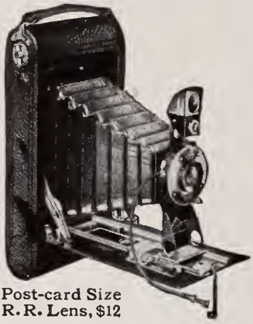

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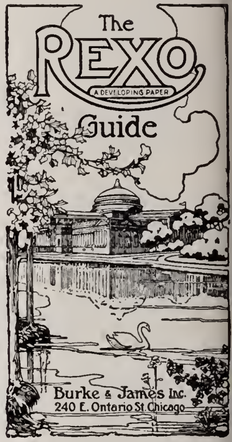

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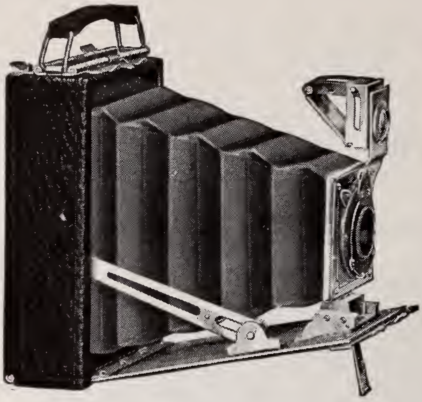

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to you just how to work in fleecy clouds, or distant mountains, o vivid foliage. These few excerpts give you the idea:

"If much foliage shows in foreground and middle distance of you picture, use first a light wash of Foliage Green, then "touch up shadow parts with Deep Green and Warm Brown and the 'high light or those parts which show up stronger and lighter, with touches o Light Yellow or Brilliant Red."

"A path or roadway in foreground should have successive washes o Warm Brown and Light Yellow. Objects such as rocks, old building fences, etc., need only a suggestion of color and for this a dilute wash o Stone Gray or Warm Brown is useful."

Velox Transparent Water Color Stamps lend themselves particularl to the very pictures you have been making during the spring and sum mer and the ones you are making right now. The vacation prints fo example, will take on themselves an added charm, a freshened intere under the brush. They will be more realistic, too. Your eye saw color not black and white.

And by the way, large prints from a few of your better vacatio negatives when colored with Velox Transparent Stamps will be th very thing for the walls of your den or library.

The Price
Velox Transparent Water Color Stamps

The complete booklet, consisting of twelve colors arranged in pe forated leaflets, making twenty-four stamps of each color, and fu directions for coloring pictures—25 cents.

Complete outfit consisting of Artist's Mixing Palette, three Camel Hair Brushes—two flat, one round, and book of Velox Transparen Water Color Stamps, price 75 cents.

KODAK TRIMMING BOARDS

There is just one reason why a pair of shears or a knife is not th ideal medium for trimming prints—neither shears nor knife can ev do the work properly. It takes a pretty steady hand and a true eye t cut even an approximately straight edge along a ruled line. An without the line most of us are hopeless. If it's wavy effects we a after, well and good, but a straight line—well, that's another propos tion. In short, trimming a print unsatisfactorily with a pair of shea

a mean, fussy job, while trimming a print perfectly with a Kodak rimming Board is the work of a moment.

Kodak Trimming Boards are made of hard wood with natural finish

ıd are equipped with rule. The blades are of high quality steel and ery "clip" leaves a clean, straight edge. The Transparent Trimming auge is a great aid in the ready adjustment of the print for even, hite margins.

It is a fact that many amateurs are a bit sparing with their trims. hey are altogether too conservative, too cautious. Too many of them em to have the idea that trimming is confined to the securing of even, hite margins around the print. This is a mistake, of course. Legion is e name of the print that could be improved by the lopping off of ank sky, or uninteresting foreground, or details at the side of the cture that are out of place and serve only to detract from the real nter of interest. The very fact that you own a Kodak Trimming oard will lead you to scan your prints carefully to see if they could ɔt be improved by trimming—and you will be surprised at the number at can be so improved.

You haven't got to O. K. your picture copy just as it leaves the mera. With the Kodak Trimming Board you can edit it a little.

THE PRICE

No. 1, capacity 5 x 5 inches - - - - -	$0.40
No. 2, capacity 7 x 7 inches - - - - -	.60
Transparent Trimming Gauge (extra) - - -	.20

THE NEW KODAK SKY FILTER

With a perfectly blank sky above it, many an otherwise beautiful ndscape would sink into the commonplace. So it is that many a land-ape that bears the earmarks of a masterpiece is "just a photograph" cause the cloud effects have been neglected. A piece of white paper n never take the place of an angry storm sky or the fleecy billowed y of a lazy day.

The Kodak Film Tank

has made the dark-room a relic and better negatives the rule.

The big link in the Kodak chain of daylight all the way.

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2½-inch Kodak Film Tank, for use with all Kodak or Brownie cartridges having a film width of 2½ inches or less, complete	3.50
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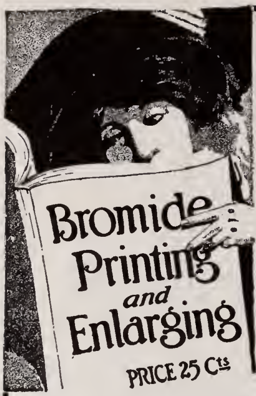

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